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Monterey, California

THESIS

METHODOLOGY FOR EVALUATION OF THE UNITED STATES ARMY COMBINED ARMS TACTICAL TRAINING SIMULATOR (CATTS)

Master's thesis,

by

Raul Hector Torres

June 1978

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Methodology for Evaluation of the United States Army

Combined Arms Tactical Training Simulator (CATTS)

by

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Captain, United States Army
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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

The Combined Arms Tactical Training Simulator (CATTS) is studied with a view towards evaluating the training effectiveness of command and control instruction. The objectives and goals of the CATTS system are reviewed, as well as the training system itself. Concepts and methodology for the evaluation of the CATTS system are presented, with a proposed test procedure outlined.

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I. INTRODUCTION

Technological advances since the last world war have helped to radically change the scope, pace and quality of life today. Now it is possible to have round-the-world conversations in a matter of seconds, and it is also possible to circumnavigate the globe in a matter of minutes. Such changes have totally revamped the way people and nations think and act. Significant changes have occurred in concepts about travel, communications, business and, even in one of man's oldest activities, warfare.

Today's technological improvements, along with the promise of tomorrow's advances, have forced senior military commanders to realize that there will be no periods of training available before deployment and few opportunities to learn from the mistakes of allies as were experienced during the past two world wars. Indeed, the victor of the next major confrontation will most likely be the one with the quickest reaction time and the best preparedness in resources and training. This is especially evident in light of the importance placed on the tactics of surprise attack by the Soviet and Warsaw Pact countries. More recently, the experiences of the last two Mid-East wars have highlighted the crucial importance of military preparedness in the modern-day conflict.

The outcome of all major ancient and modern military conflicts when analyzed in any depth are seen to be based on preparedness--not luck [20]. As the modern army becomes more technologically sophisticated and as the potential battlefield becomes more diverse, the problem of training becomes more complex and more critically important to solve. The commanders who will manage this complex battlefield must be very well trained in controlling the myriad of advanced weapons systems and equipment and also of analyzing the copious information available to them.

Traditionally, the only way to become trained in battlefield command and control was either by actual combat experience or by field maneuvers. The former is rather infrequent and the latter is very expensive and falls short of portraying the broad spectrum of combat conditions which may exist worldwide. The inexperienced brigade or battalion commander sent to distant and unknown lands faces formidable problems for which field maneuvers can only partially prepare him at best. This situation has created the need for a training system which can augment the traditional field exercises and classroom learning by offering a training experience based on realism with regard to the critical elements of terrain, resources, weather, personnel, and enemy tactics. Just such a training system is the Army's Combined Arms Tactical Training Simulator (CATTS).

As was mentioned previously, one way to become trained in battlefield command was through actual combat experience.

Yet a study by the Pentagon's Systems Analysis Office [20] during the last years of the Vietnam conflict revealed that casualty rates in U.S. battalions commanded by new and inexperienced officers was twenty per cent higher than in those battalions commanded by more experienced officers. Obviously, that is an unacceptable rate. This statistic pointed out to senior military commanders that the training received by young officers was not sufficient to help overcome their lack of experience.

Until a few years ago the training received by prospective battalion and brigade commanders was limited to classroom exercises on the theory of command and control, along with the standard courses of military tactics and strategy and the principles of leadership [20]. The only opportunity for a battalion commander to put the theory in practice within a training environment was during a command post exercise (CPX) or a field training exercise (FTX). This was only possible after the officer assumed command of a functioning unit. A command post exercise is a manual simulation, that is, the computations involved must be done by hand, and although some are aided by high capacity calculators (mini-processors), they all suffer to one degree or another from the main drawback of the CPS: lack of realism [10]. A field training exercise (FTX) is a training device used to acquaint the commander and his staff with the principles, procedures, and problems of tactical field maneuvers and combat techniques while actually controlling his unit;

fully functioning and fully manned and equipped [7]. However, in peacetime field training exercises normal peacetime priorities are in effect and the administrative and logistical details of garrison life must still be observed. This is a distraction that can only be eliminated during combat. Furthermore, in a field training exercise the commander cannot get involved in the fast-moving situations characteristic of warfare and also, the weapons systems cannot fire in a way that the true effect can be measured. Weapons effects must be simulated, since it is culturally unacceptable to have two-sided live-fire exercises. Thus, weapons effects (and their attendant operational effects) are not part of field exercises.

The key to the effectiveness of CATTS as a training system is that the realism that was missing from the aforementioned traditional methods has now been achieved. Using this training system the commander and his staff must evaluate information from the subordinate units and make decisions at the same, often man-killing, tempo as they would in actual combat. It is the purpose of this thesis to describe the CATTS system and to propose methodology and concepts for the evaluation of such a system.

II. OBJECTOVES OF THE COMBINED ARMS TACTICAL TRAINING SIMULATOR

A. PROBLEMS WITH TRADITIONAL TRAINING TECHNIQUES

Historically, the best battlefield commanders have been those that have weathered the tribulations of combat previously, those commanders that have faced and overcome the stresses of command under pressure from actual conflict [20]. It is, of course, impossible to have seasoned veterans in all key command positions and it is just as difficult to train a peacetime commander in the skills and techniques of command which can be acquired only through actual combat. It is for these reasons that a more realistic training approach was desperately needed by the Army; an approach that succeeded where the command post exercise and the field training exercise failed.

There are a number of teaching and training methods that have been used in the past [7]. Some of the most common are:

1. Terrain Model Exercise
2. Map Exercise
3. Terrain Exercise
4. Tactical Drill Exercise
5. Map Maneuver
6. Command Post Exercise
7. Field Exercise
8. Field Maneuver

9. Tactical Exercise Without Troops

10. Unconventional Warfare Training Exercise

All of these map and tactical training exercises vary greatly in content and in scope. These exercises may be one-sided or two-sided. In a one-sided exercise the opposing force is represented by an umpire or a controller who makes decisions on casualty assessments, maneuver and tactical effectiveness, etc.. In a two-sided exercise the forces involved maneuver against each other without firing live ammunition. In this case the controllers or umpires monitor, judge and arbitrate engagements of both sides to keep the exercise within the stated objectives. Any of these tactical exercises listed above may be of two modes: free or controlled. In a free exercise both sides are permitted total freedom of operation during the course of the exercise. However, in a controlled exercise one or both sides are constrained to act according to a preconceived scenario which insures that the objectives of the exercise are fulfilled. As was previously noted, the umpires or controllers of these tactical exercises are responsible for the evaluation of the quality of performance of individuals, units, staffs, equipment and weapons systems; and the adequancy of concepts, procedures, and techniques employed in the exercise.

Effectively controlling a tactical exercise while simultaneously permitting the tactical exercise scenario to realistically portray the actual combat environment presents a

most difficult task for exercise control personnel. More significantly, as the complexity of the controllers' job increases and more demands are placed upon them, the realism of the entire exercise is placed in jeopardy. The value of the exercise as a training medium is often directly proportional to the degree of realism portrayed in the tactical exercise. This then is the single most important deficiency of the conventional tactical exercises--the inability to depict the actual battlefield situation with a high degree of fidelity. As S. L. A. Marshall once wrote: "It is not within the ingenuity of man ever to fully close the gap between training and combat."[12]

It is also a very well known fact that many untried commanders who were once classified as competent theoretical tacticians have met defeat when they encountered the realities of armed conflict. What, therefore, separates the successful commanders from those who failed to meet and overcome the challenge? Colonel Wesley W. Yale has written:

> "The art of tactical control is, therefore, more than a study. It rests on practice. Just as an artist cannot paint a picture solely by reading books about Michelangelo, a commander cannot train himself by reading about the great captains.
>
> "The control of battle is more a matter of techniques than of tactics--the positioning of the commander at various stages of action, the organization and use of a mobile staff, the measures needed to ensure precise timing of fire support with maneuver and the correct and timely use of ground and air command transport. In addition, perhaps obviously, there must be physical familiarity with the tools of control such as radio and computer input/output display. Less obviously, there is a vital need to understand the organization of communications and communications

> personnel, to the end that the commander is not snowed under by trivia, but, rather, works only with essential, decisionmaking information." [20]

The United States Army has recognized the lack of realism in those map and tactical exercises mentioned previously; and, furthermore, it has also recognized that these "techniques" that Colonel Yale mentioned are the key to fully preparing today's commanders for the battlefield of tomorrow. It was toward this end that the Combined Arms Tactical Training Simulator (CATTS) was designed.

The CATTS system was developed for the Army by TRW Systems Group, Redondo Beach, California. This system is based on the concept that it is within the state of the art to model battlefield conditions and conflict outcomes to an accuracy level which is commensurate with the training needs of battalion commanders and their staffs. In effect, the CATTS system provides realistic assessments for the consequences of decisions by the trainee battalion commander by using complex and detailed computer routines which simulate not only the basic tactical unit functions, but also the interplay of these units with the selected battlefield scenario, enemy situation, weather conditions, etc.

B. SIMULATION TRAINING

History indicates that one of the most decisive factors in winning and losing wars is the adequacy of training and the motivation of soldiers, sailors, airmen and marines who make up the combat forces. However, it has been very difficult

to achieve and maintain a constant high state of combat readiness in peacetime without jeopardizing the safety of the trainees and their equipment and incurring prohibitive training costs. Further, the rather high turnover rate of personnel has been a significant impediment to achieve this high state of preparedness. High morale in combat units during peacetime is directly proportional to the state of training in these units: the better prepared a unit is for a certain mission, the more willing it will be to perform such a mission. New advances in technology have provided revolutionary capabilities for safer, more economical, and effective training in operational, maintenance, and combat skills by the use of simulation.

Most simulators today in the Department of Defense are used to help teach people how to operate a major weapon system, i.e., a piece of hardware--how to fly an airplane, drive a tank, or dock a ship. In the civilian sector, simulators are used in high-school driver education classes to teach students how to drive cars. They are also used by the airlines for pilot proficiency training.

The Defense Department is currently developing or has developed a whole family of simulators which can provide realistic, effective training at reduced costs. At one end of the simulation spectrum there are the pilot and aircrew simulators which provide a high degree of realism in visual and motion cues. These devices, with their impressive array of mechanical, electronic, and visual subsystems, have

received the most public attention. The Advanced Simulator for Undergraduate Pilot Training (ASUPT) developed by the Air Force Human Resources Laboratory [16] is an example of this modern technology. This simulator embodies the state of the art in technology at this point and is the epitome of today's flight simulation. As the trainee sits in the simulator cockpit, he sees a wrap-around computer-generated image which is spatially accurate with regard to the airborne flight and ground track of the simulated aircraft. The image also is coupled to the motion base of the simulator so that the visual scene accurately depicts positional information of the real world.

At the other end of the spectrum, clever applications of modern technologies--eye-safe lasers, cheap microprocessors, and new advances in low-cost electronic devices--have made possible realism in combat engagement simulation even for infantry and armor. The probability of casualties among combat troops is greatest during the first few weeks of combat experience. In close combat concealment and cover are the keys to survival. Exposure to the lethality of modern weapons with their high accuracy and firepower means high casualty rates. Therefore, new training techniques are needed to simulate combat conditions realistically between two opposing forces and to teach soldiers to do the correct things instinctively in the event of an actual armed conflict.

In order to provide this realistic combat training, the Department of the Army has developed a system based on low-power lasers and inexpensive microprocessors to teach battle skills for a two-sided combat situation. This system is called the Multiple Integrated Laser Engagement System (MILES). This system actually simulates the exposure of a soldier to the lethality of weapons, provides data for a critique of a two-sided engagement, and permits training repetition.

Training units are furnished with rifles, machine guns, tank and antitank guns that are equipped with eye-safe lasers. Sensors are mounted on each soldier, vehicle, and weapon and connected to a microcomputer carried by each man or weapon. On the infantryman the sensors and the microcomputer are mounted on the belt harness and helmet. When a weapon is actuated, a blank round is fired by the weapon and a light beam containing a distinctive code is emitted from the laser. Any sensor intercepting the beam records a lethal hit if the sensor is located in an area where a hit from that kind of weapon would normally disable the target. The soldier's computer is programmed so that a hit in a vital area from any weapon is likely to be a kill. The microcomputer informs the bearer if he has been hit and automatically disables his weapon, removing him from the exercise.

The results of preliminary exercises with this type of system have been most impressive [10]. It has generated

real enthusiasm from recruits and experienced veterans alike. This system puts new challenges and excitement into military field training and teaches skills that formerly could only be learned in battle.

The advantages of simulation training are not restricted to training effectiveness alone. An equally important aspect of simulation training is the greatly reduced cost with an associated high degree of training effectiveness. In the parlance of Operations Research, such systems have proven to be cost effective. The Department of Defense has accelerated the procurement of flight simulators and increased their use in both training and operational squadrons [16]. The original motivation for this step can be found in the fact that fuel costs have increased well over 300 per cent since the last Mideast War of 1973. The record shows that in fiscal 1974 the Air Force flew about one million hours less than in fiscal 1973, but it cost one billion dollars more to fly these reduced hours [16]. The Defense Department has consequently submitted to Congress a procurement request of almost one billion dollars for the fiscal 1977, 1978, and 1979 years for simulators for new and existing aircraft [16].

Studies on the comparison of the operating costs of seventeen aircraft and their respective simulators indicates that, at one extreme, aircraft operating costs are thirty times greater than simulator operating costs, while at the other end of the spectrum, the operating costs for certain helicopters are only three times greater [16]. The median

value shows that aircraft operating costs are over ten times greater. The Department of Defense anticipates that the overall fiscal 1978 flying-hour savings due to the use of all flight training simulators to be 676,000 hours which will also result in the savings of 566 million gallons of fuel.

Simulation training seems to be both training and cost effective in the particular instance of flight systems simulations; however, the payoff for the military may be just as great in the field of combat engagement simulations as indicated in Commanders Digest of 15 August 1974:

> "Simulation equipment used in both ground and aviation related training has unlimited potential and provides an innovative and cost-effective teaching tool. This equipment employs the latest state-of-the-art in educational technology and methodology.
>
> "Although ground-related simulation equipment has not yet been developed to the high state of sophistication of aviation-related simulation equipment, ground-related simulators are designed to improve the learning process and to assist in producing a better trained individual. They are neither designed nor intended to replace hands-on training, but rather to make the hands-on training more meaningful and effective."

It is just this type of ground-related simulation which the Army is employing in the CATTS system. The training is aimed at the brigade and battalion level and seeks to implant an appreciation of tactical requirements during a moving situation. In the recent past, the Army, Navy, and the Marine Corps have developed [10] some highly sophisticated electronic simulation devices for command training; however, these tools do not get to the root of the command and control problem. To repeat, it is not so much tactical

training that is needed as is the methods or techniques of exercising command. The requirements for these techniques are greatest at the brigade and battalion task force levels. Here the prospective leader is a field grade officer schooled in the theory of military tactics without, in all probability, mastering the techniques of command. It is this officer who is the prime target for simulation leadership training.

III. CATTS SYSTEM OVERVIEW

A. THE SYSTEM

The present day commander has many more variables to deal with and generally much less time to deal with them than his counterpart of just a few decades ago. Such variables as the weather and the terrain play as important a role as always, but today the commander must also be knowledgeable about the latest weapons systems, sensors, rockets, missiles, satellites, lasers, etc. The Combined Arms Tactical Training Simulator provides the means to realistically portray all of these variables and the terrain and the weather. It was conceived as a solution to the problem of providing effective training for battalion field commanders and their staff officers. In particular, the desire was for an automated training aid which would approximate the decision-making experience which can now be obtained only through actual participation in combat operations.

The battalion commander and his staff (also referred to as players or as trainees) are housed in a realistic mock-up of the battalion Tactical Operations Center (TOC), which contains fully functional government-provided radios and field telephones modified and connected to a sophisticated solid state communications system. The TOC also contains a simulated radio teletype (RATT), microphone monitor pickups, a public address system, and a multi-directional sound system.

All of these devices are monitored and controlled by a team of controllers.

The trainees give commands to and receive reports from these controllers who also act as subordinate commanders (company, platoon). However, instead of these "subordinate commanders" dealing with real troops, real enemies and a real environment, they perform the equivalent function but deal with the computer instead. Figure 1 shows this equivalence in a diagrammatic fashion. When a trainee uses one of the communications devices, he communicates with a controller who plays the role of the person who would normally be at that particular communications net (i.e., higher, lower, adjacent commands, artillery, air support, etc.). Conversations anywhere within the TOC can be monitored by any controller. All voice communications are recorded on a twenty-track audio recorder. Each radio network may have static and/or jamming added to it at the discretion of the controllers. Directional battle and motor noises can be introduced by the controllers over the multi-directional speaker system.

The training environment provided is a physically realistic one. The trainees operate in a physically familiar setting using familiar communications equipment to communicate with the outside world. Their only source of information about the course of the battle comes over the communications system. From information provided by the controllers, the trainees must work as a team to maintain an accurate

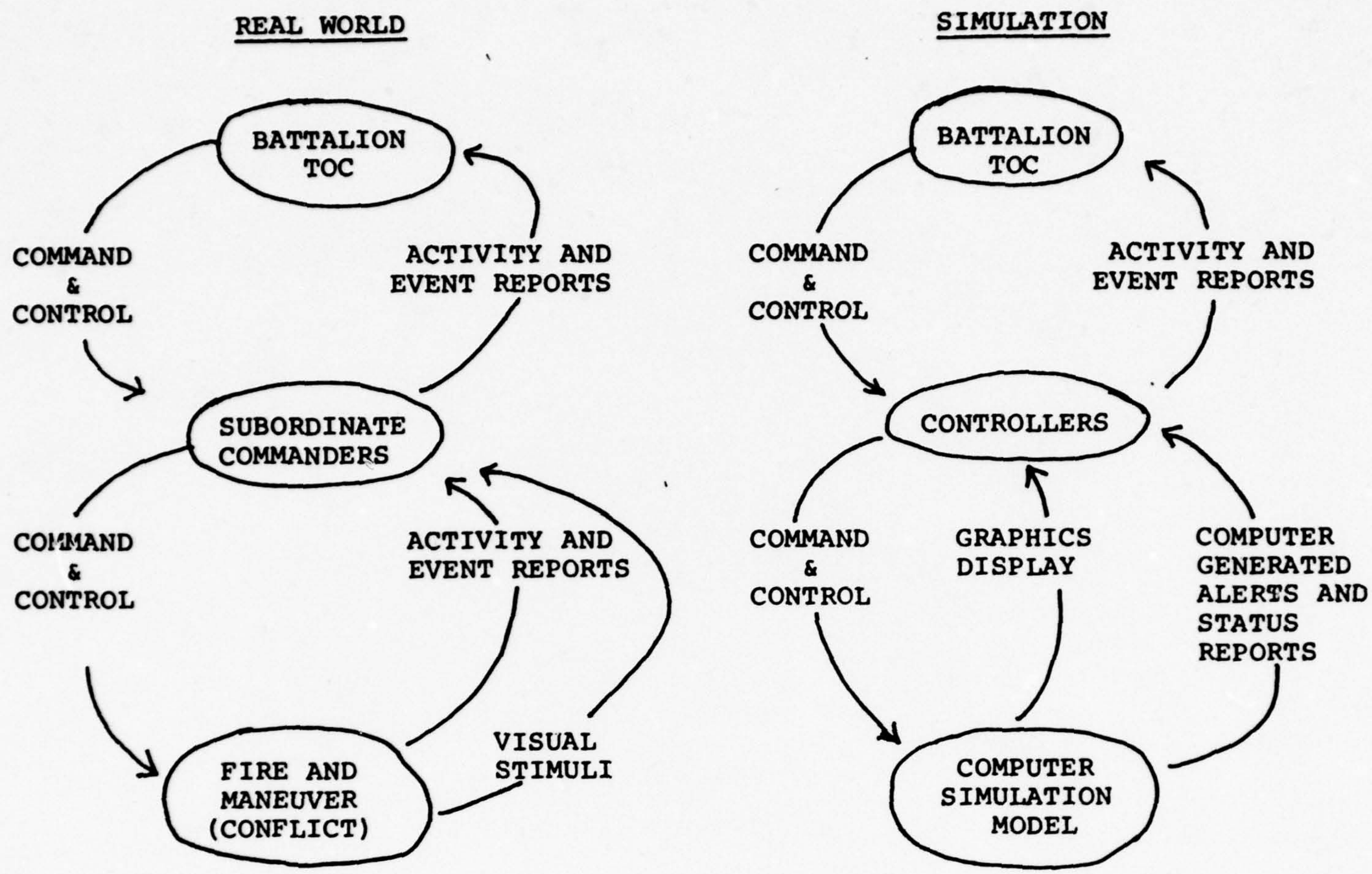

Figure 1. REAL WORLD versus SIMULATION
(Command, Control, and Reporting Structure)

picture of what is going on, make command decisions under stress in real time, and communicate their decisions to the controllers playing the appropriate roles.

The technical problem the CATTS system attempts to solve is that of giving the controllers an aid to calculate battle outcomes rapidly enough and realistically enough for training needs without constraining the freedom of action of the trainees. This is accomplished through the use of a large-scale computer system on which the battle is simulated by a mathematical model which calculates the battle outcomes, and a set of sophisticated interactive graphics programs and display devices which allow two-way communication between the controllers and the simulation model.

Thus we have a closed loop system in which the simulation model calculates battle outcomes and displays those outcomes to the controllers as alphanumeric messages on the alphanumeric display devices, and also as fully colored military graphic symbology overlaying a full color military map on color television monitors. The appropriate role-playing controllers relay information to the trainees over the communications system. The trainees react and relay their orders and requests for support back to the appropriate controllers over the communications system. The controllers use graphic tablets and the color displays plus a complex set of command and control computer programs to enter the full spectrum of necessary military commands to the math model, which updates

the necessary model variables to carry out the commands, thus changing all future battle outcome calculations. This closed loop, interactive system frees the controllers to dedicate their efforts to role playing and to the training process, rather than to the calculation of casualties, movement rates, etc.

The basic CATTS system also includes an umpire or observer monitor area, which allows students, senior officers, or observers to monitor all aural communications and all color graphics displays without actually participating in the exercise. In this way a group of students, for example, can watch, listen and learn from the mistakes of the trainees in the TOC.

A further system feature is the simulation control system which allows the simulation to be frozen, replayed, restarted, or reinitialized at the command of the controllers. The simulation might be frozen during classroom break periods or for an admonitory warning over the public address system. A replay might be used to show trainees (gathered in the umpire area) what had "really" occurred and/or where they went wrong. A restart might then be used to reset the exercise to a point just before the "fatal" error was made, or to illustrate the outcome using a preferred tactic or technique. Reinitialization to the same or a different scenario might be used to show that a tactic favorable under one set of circumstances can be disastrous under another.

Many different kinds of diagnostic aids are available to assist the evaluation of trainee performance. Status reports are available throughout the game. Post-game processors produce a report showing the change in levels for every unit in the exercise, also a summary of red and blue casualties, and a sorted summary of all alphanumeric messages produced during the game. In addition, the replay of selected portions of the simulation with the appropriate color displays can be a valuable aid in reconstructing the events of the exercise. The audio communications can also be played back with or without the color graphics to aid in evaluating trainee communications techniques or as an aid in the reconstruction of events.

B. THE SYSTEM HARDWARE

The CATTS system is housed in four separate rooms--the player room, the camera room, the control room, and the computer room (see Figure 1). The only software interface to the player room is with the teletype, which serves as a simulated radio-teletype (RATT). The camera room contains three color television cameras with software controlled pan, tilt, and zoom motors. The control room contains the audio recorder, the game clock, and three controller consoles. These consoles are the primary interactive software interface. The three consoles are used as: a command and control station which oversees the entire conflict, an enemy station, and a fire support station. The computer room houses the computer, a XEROX Sigma 9 Model Three and the color graphics display device. Numerous other peripheral devices which serve to assist

the controllers in the course of the simulation are listed in the literature [13].

C. THE SYSTEM SOFTWARE

The CATTS software is divided into two types--small, fast, interactive programs which must have fast response to controller inputs, and the large CATTS mathematical model. The interactive programs run in the foreground mode [13], and are principally concerned with communicating data and commands between controllers and the simulation model. The simulation model (mathematical model) runs in the background mode, calculating battle outcomes, casualties, etc.

The CATTS simulation model is a large, detailed, complex digital Monte-Carlo simulation of the tactical battlefield environment. It is time-step simulation model with time-steps of one minute. It calculates, for each minute of battle, the detections, engagements, fires, casualties, movement, and environmental effects for up to ninety-nine units. The baseline scenarios have units that vary in strength from a squad to a ballation, with the normal level of platoon for friendly units and company for aggressor units.

Because the model is not interrupt driven [13], it runs as a background program, and is often referred to as the "background software." The model is functionally divided into ten modules, each with a specific function. The following is a list of these ten modules and a brief description of their implementation:

1. Executive and Simulation Control Module
2. Environmental Module
3. Target Acquisition Module
4. Ground Fire Module
5. Ground Movement Module
6. Engagements Module
7. Input/Output Module
8. Air Module
9. Command and Control Module
10. Miscellaneous and Ancillary Module

1. Executive and Simulation Control Module

This module has the task of overseeing mathematical model execution. It moves the correct overlay segments to/from core memory as required, directs the execution of the various other modules, handles the interface with the foreground programs, saves the data necessary for replay and restart on disk files, and performs most of the functions of simulation control.

2. Environmental Module

The Environmental module has two purposes. One is to calculate the existence of lines of sight between eligible ground units, considering terrain relief and vegetation interaction. This is accomplished by a complex model using a large terrain data base developed from Defense Mapping Agency provided data.

The second purpose of the model is to update the global weather conditions, which include:

*temperature

*relative humidity

*weather class

*meteorological visibility

*ambient light level

*wind velocity

*wind direction

3. <u>Target Acquisition Module</u>

The target acquisition module determines the occurrence of detections between eligible pairs of units and generates alphanumeric alert messages when detections occur. Many environmental and tactical considerations and a wide range of sensor types have been modeled.

4. <u>Ground Fire Module</u>

The ground fire module is a complex, detailed model which allocates and controls the fire of all ground weapons modeled in CATTS. It computes firing rates, casualties, and ammunication expenditures for each weapon in each unit each time-step.

5. <u>Ground Movement Module</u>

The ground movement module controls and directs the movement of all ground units in the area of operations. At each time-step, each unit is examined to determine whether it should start or stop moving. For moving units a movement rate is calculated based on tactical considerations, existing and new engagements, suppression, and environmental factors.

Units may move singly or as part of an operational grouping. The disruptive effects of obstacles to movement rate are also modeled.

6. Engagements Module

The purpose of the engagements module is to cause ground units in the model to respond in a tactically realistic way to enemy fire and/or proximity. It determines when units will fire direct fire weapons, when they will form engagements, and when they will break them off.

7. Input/Output Module

The input/output module consists of the portions of the model which are concerned with input or output. It includes those routines which initialize the data base, those which produce the line printer status reports, those which generate alert messages, and those which produce alerts on the visual display monitors.

8. Air Module

The air module updates location, direction, speed, and altitude of each air unit according to individually input flight plans. This occurs at intervals of one-quarter minute or less. For each quarter-minute air/ground interactions are calculated, including detections, firing, air weapons delivery, and casualty assessment.

9. Command and Control Module

The command and control module performs the necessary data base updates for both the interactive and the

table-driven command and control in the simulation model. The interactive portion processes the command and control event notices received from the foreground Command and Control Program. The table-driven portion uses a tabular set of input decision rules which determine changes in unit status if the conditions specified in the table are met.

10. <u>Miscellaneous and Ancillary Module</u>

The miscellaneous and ancillary module is a set of service routines used by other modules to perform common calculations of such things as line intersections.

D. THE SIMULATION MODEL AND ITS DATA BASE

From the preceding discussion, it is clear that the heart of the CATTS system is the software and the data base. The modeling of a battalion-level operation means that everything of significance which occurs in battle must be represented in the simulation, i.e., a column of tanks heading toward an objective must traverse various kinds of surfaces such as roads, sand, dirt, and swamp. Each different soil and road type will result in an effect on the speed of the column. If a commander orders a tank platoon through impenetrable vegetation, it will not make it if the data base and simulation model are properly designed. If a mortar platoon is engaging the enemy and begins firing out of range, the enemy attrition will be minimal or not at all and, in addition, the enemy will then be aware of the presence and location of the attackers.

Due to the size and complexity of the CATTS model, a "data-driven" concept has been employed. Simply put, this concept allows one model (the model of a gun, for example) to be used for many types of guns by using different data to drive the model, resulting in a variation of weapon ranges, lethality, firing rates, and aural levels. The attrition of friendly and enemy forces is calculated based on many variables including concentration of force, deployment of forces, and weapon types. Table I shows the simulation model used in CATTS. Furthermore, Table II and Table III represent some of the command and control capabilities of the CATTS system.

Real battles are fought on real terrain and a knowledge of the terrain (soil type, relief, vegetation, roads and rivers) is essential to good tactics. In CATTS the terrain data are modeled mathematically; events which would normally be affected by terrain in a real conflict are also affected in CATTS. Lines-of-sight from one point to another can be obscured by relief and vegetation; the movement of personnel and equipment is a function of the terrain on which they travel. The commander who does not know and make good use of terrain can suffer severely at the hands of an opposing commander who does. CATTS presently has a digitized terrain data base size of 27 x 100 kilometers. Elevation points are stored every twenty-five meters for a total of 4.32 million elevation points. Elevations lying between the twenty-five meter coordinate points are calculated by interpolation.

TABLE I

The computer simulation model contains:

* Digitized terrain data
  (topography, vegetation, roads)

* Weapon models
  (range, lethality)

* Sensors
  (range, accuracy)

* Movement models
  (men and equipment)

* Weather effects

* Engagement of red and blue forces

* Line-of-sight algorithms
  (interact with terrain)
  Attrition algorithms
  (red and blue)

* Automatic status report generation

TABLE II

Command and Control capabilities provided by the CATTS system:

* Change the global weather class
* Execute a preplanned mission
* Deactivate red or blue units
* Resupply red or blue units
* Perform red or blue task organization
* Create red or blue air strikes or air reconnaissance missions
* Issue red or blue air defense commands
* Maneuver red or blue units or task forces
* Create, move, delete red or blue control points, lines, or areas
* Relocate red or blue units instantly
* Issue red or blue fire/no fire commands for any or all weapons in a unit

TABLE III

Simulation control capabilities provided by the CATTS System:

* Reinitialize the game to any pre-defined scenario

* Back up to an earlier point in the current game and restart from there

* Back up to an earlier point in the present game and replay it exactly as it happened. Allow full graphics interactive capability. Replay at controller-specified speed.

* Terminate the replay in progress

* Terminate the present game.
  Print prespecified post-game summaries.

* Freeze the present game. Allow full interactive graphics and command and control capabilities during the freeze, but do not allow model to execute.

E. CATTS -- THE TRAINER

The CATTS system was originally installed at Fort Benning, Georgia, in March, 1975. After successful acceptance testing, the system was used to train several groups of players from various areas of the Army. A player group consists of up to twenty personnel, including the battalion commander, i.e., the normal staff complement of a battalion TOC. Each exercise period is presently four hours long and the entire exercise, including tape recordings of player-controller and player-player conversations is preserved on mass storage. Replay of the exercise is one of the most significant attributes of CATTS. Umpires, who have monitored the exercise on Cathode ray tube (CRT) displays and then have taken notes regarding tactical decisions made by the player-commander, attend the replay and detailed discussions of these decisions are carried out during the replay. The replay may be backed up or stopped at any desired game time to view specific areas of the exercise. Different tactical situations may be used to train the players on specific tactical problems. Since the CATTS engagement game is free play (units can be anywhere and move in any direction) various defense and attack postures can be structured to fine-tune the training as desired. When one views an exercise in progress from the TOC area and hears the static, the jamming and the voices of the controllers acting as company commanders who are receiving enemy

fire, the realism is quite convincing. Since the exercise is real time, the decisions and actions of the players must also be at the real-time rate; no time can be wasted in lengthy analysis of fast-breaking situations and efficient use of personnel and time is an important ingredient of the training regimen.

The Army at the present time is evaluating CATTS for possible future uses. Some important questions associated with possible future uses of the CATTS system are:

* How is it best used to train?
* How does it fit in the whole training and education spectrum of the Army?
* How can it be used for training troops on real terrain data in a potential conflict area of the world?
* How can the system be organized to perform unit training at remote posts?

These and other questions regarding the data base and some particulars of the hardware must be answered before CATTS can realize its full potential in the training inventory of the Army. Planning is another area in which a CATTS-like concept could be of significant help. In the same way that "contingency training" would incorporate the particular reality of the potential conflict area and enemy force structure, the planning use of CATTS would allow the decision makers at division level, for example, to plan the strategies, tactics, and contingencies based on data which represents the

real environments and force structures involved. Various scenarios could be used which cover a reasonable spectrum of conflict types and intensities, and many of the critical variables of warfare, such as resource allocation, lines of communications, the use of terrain, enemy tactics, etc., could be analyzed in detail.

IV. CONCEPTS AND METHODOLOGY FOR EVALUATION OF THE CATTS SYSTEM

On the surface, the Combined Arms Tactical Training Simulator appears to be just the educational and training tool that the Army has for so long needed to bridge the gap between the seasoned combat veterans and the young inexperienced and untried officers. Certainly, it would be foolhardy to blindly accept as true all of the claims made for the CATTS system by its developers and proponents. Therefore, before full scale implementation and utilization of the system began the Army set about validating the CATTS trainer, i.e., evaluating the entire system to determine if it was meeting the initial system objective of providing a true-to-life simulation of the battalion commander's combat dilemma. This validation study began in 1975.

While this seems like a wise precaution to take before a full-scale implementation of the system takes place, there is a need for a much more comprehensive evaluation of the CATTS system and, specifically, its impact on training. It would certainly be ingenuous to believe that the CATTS system, once validated, was fully preparing the modern commanders for a future conflict. If the CATTS system was blindly accepted as the ultimate trainer and no follow-up studies conducted, then a fault or deficiency of the system would not make itself evident until the next major armed conflict

and that, as agreed unanimously, is far too late. There is, undoubtedly, a need for a constant and comprehensive program of evaluation of this system if the Army is to make full use of the CATTS system potential. This evaluation is the topic of this chapter.

The CATTS system, which was first set up at the U. S. Army Infantry School, Fort Benning, Georgia, in June 1975, cost slightly more than $4 million to develop and costs about $100,000 a year to run, mostly in computer software maintenance [16]. Some of the original development cost of $2.7 million (under contract to the Project Manager for Training Aids in the Materiel Development and Readiness Command) was in eighteen months' worth of rental time on the computer which the Army later decided to buy outright for about $600,000.

The balance of the original cost was a million dollars' worth of software models developed by TRW Systems Group under contract to the Defense Department's Advanced Research Projects Agency. Some observers believe that the system was cheap at the price, noting that it cost the Army about $2 million to develop a new helmet [16]. Formal cost and cost effectiveness analyses are still underway, although some CATTS advocates fret that the rigid rules of this process will not account for the value of some of the totally new capabilities that the system possesses.

The purpose of this chapter is to address the topic of system evaluation for the CATTS system and, more specifically,

to answer the following questions:

* Why do we want to evaluate the system?
* How should we evaluate it?

Further, a test concept is presented for the evaluation of the CATTS system.

A. WHY

At no other time in history has Congress placed so much pressure on the armed services to support and justify their major expenditures. The clamor of public opinion and many complex budgetary constraints have forced the Congress to insist that all major agencies of the Federal Government endeavor to trim expenditures to the bare essentials. This Congressional pressure has as one of its more visible focal points the expenditures of the various armed services on new and expensive weapons and training systems. In order to counter this Congressional pressure, all of the armed services have had to establish as fact that all new proposed weapons and training systems fill a definite and crucial need in this nation's overall security strategy and also that the systems in question meet or exceed their design criteria so as to justify the expenditures for their acquisition.

The critical need, as discussed in Chapter Two, that the CATTS system fulfills is that of training today's inexperienced and untried commanders so that they may be able to cope with the complexities of future conflict.

B. HOW

In the discussion of the methodology for the evaluation of a system such as the CATTS system, three topics will be dealt with:

1. Measures of Effectiveness
2. System Effectiveness
3. Training Effectiveness

1. Measures of Effectiveness

Before a system such as CATTS can be evaluated, it is essential that the goals of that system be clearly stated so that the analyst possesses an adequate basis for comparison and evaluation. The primary goal of the Combined Arms Tactical Training Simulator is to improve the outcome of any future armed conflict through the enhanced preparedness of the battalion commander and his staff. Specifically, this preparedness consists of an increased proficiency in commanding and controlling a combat unit to its fullest potential.

The Operations Research literature [18] is quite specific as to how to proceed with the evaluation: the analyst must first select appropriate qualitative measures of a system's effectiveness and then the analyst must seek methods of quantifying these measures so that a comparative evaluation of a system's worth can be conducted. This, unfortunately, is the most complex and difficult part of the evaluation process. It is a relatively simple matter to come up with qualitative measures for a system such as CATTS. For example, some qualitative measures may be: increased enemy casualties,

decreased friendly casualties, greater terrain gains, improved battle outcomes, etc. However, in order to quantify these measures the analyst must have access to actual battlefield outcomes, a commodity that is quite impossible to acquire during peacetime.

It is for this reason that "surrogate" measures must be used. In some cases, even though a final valid evaluation cannot be made with surrogate measures, at least a preliminary tentative evaluation can be attempted, until it is possible to acquire enough data to quantify the system measures of effectiveness. There are two classes of surrogates available:

a. Intermediate (Enabling) Tasks

b. Terminal Tasks (Terminal Evaluation).

a. Intermediate (Enabling) Tasks

Behavioral scientists [1, 11, 15, 19] have described intermediate or enabling tasks as those tasks that must be satisfactorily accomplished prior to the attainment of a major objective. For example, there are several steps on the road to becoming an airline pilot. First, a pilot must attain a commercial pilot certificate, then he must attain an instrument pilot rating, then a multi-engine rating, and finally he must attain an airline transport pilot certificate. These are some of the intermediate tasks or requirements that must be accomplished prior to becoming an airline pilot. Similarly, there are many varied intermediate tasks that must be mastered by a battalion commander and his staff prior to successful command of a combat unit is achieved. Just some of these

tasks are:

* Be thoroughly knowledgeable about capabilities, effects, limitations and requirements of both friendly and enemy weapons systems.
* Be thoroughly familiar with mission, capabilities, tactics and probable courses of action of enemy forces.
* Be capable of effectively maneuvering friendly forces in such a manner as to enhance the probability of victory.
* Be capable of managing the myriad details involved in the coordination of fire support from artillery, helicopter gunships, tactical aircraft, and naval gunfire.
* Be able to accurately assess the situation on the battlefield from the reports of subordinate and adjacent units.

These are just a few of the many intermediate tasks that can be listed as being essential for assuring the success of a battalion commander on the battlefield.

These behavioral scientists referred to previously argue that armed with the results of the evaluations of significant intermediate tasks they can evaluate the relative worth of a training system. This author must agree that an analyst can make a preliminary assessment of a system's worth; however, a more thorough analysis must be ultimately based on the terminal tasks.

b. Terminal Tasks (Terminal Evaluation)

Terminal tasks are defined as those goals and objectives that are the designed intentions of a training

system. For example, a terminal task or terminal evaluation for a flight school could be the percentage of students who successfully graduate with their pilot certificates. With regard to the CATTS system, the terminal evaluation is the improvement of battle outcomes. Again, if the medium for the evaluation is actual combat itself, then results will be impossible to attain during periods of peace. However, through the use of training devices such as tactical field exercises it is possible to simulate, to some degree, actual battlefield scenarios and thus, to some degree, attain an evaluation of the battalion commander's ability to command and control his unit.

It is the opinion ofthis author that since the overall system objective of the CATTS trainer is to improve the outcome of battles, it would be more appropriate to study the results of a terminal task evaluation. Certainly, the CATTS trainer would conceivably score well if evaluated on the basis of the intermediate or enabling tasks, but this is not the goal of the CATTS system. Instead, the Combined Arms Tactical Training Simulator is designed to take the battlefield commander's skill in accomplishing these intermediate tasks, exercise and improve these skills, and teach the commander how to use these skills simulatneously and integrate them through the experiential-type training situation. The objective of the CATTS system is to improve the "fighting ability" of units: it is precisely this factor that analysts should test for in the evaluation results.

J. G. Taylor has written [18]:

> "The effectiveness of any military system may be defined as the extent of success to which the system may be expected to achieve a set of objectives. These objectives may either be explicitly stated as specific mission requirements or be implicit in the system's operational deployment. The objectives of the system are frequently determined by its relations with higher echelon systems. Judgment and experience must be exercised by the analyst to determine the extent to which these 'super systems' (and also subsystems) must be considered for identifying objectives. The defining of the system and identification of its objectives is the development of a qualitative effectiveness concept.
>
> "The quantitative expression of the extent to which specific mission requirements are attained by the system is referred to as 'a measure of effectiveness.' The choosing of measures of effectiveness for a system under consideration is most successfully done by quantifying a previously conceived qualitative effectiveness concept.
>
> "Very often failure to choose the appropriate measures of effectiveness can lead to completely wrong conclusions as to preferred alternatives. This usually has resulted not from failure to choose measures which describe system performance but from lack of adequate consideration of system objectives. Frequently, the most desired objectives of system performance are not explicitly stated. It should also be noted that the objectives of a system may vary with its mode of operation or type of mission."

Thus, the ultimate objective of the CATTS system should be constantly referenced during the selection of appropriate measures of effectiveness for its evaluation. This ultimate objective is the improvement of battle outcomes, and it is for the same reasons that Taylor has given that this author supports the evaluation of the CATTS system based on the terminal task evaluation.

2. System Effectiveness

P. Hayward [18] has outlined four factors upon which the system effectiveness of a military training system

depends: a. Enemy Force/Hardware Capabilities

b. Friendly Force/Hardware Capabilities

c. The Combat Environment

d. The Mission.

a. Enemy Force/Hardware Capabilities

The training system must be capable of accurately representing modern enemy tactics and weapons employment/effects in order to give the trainees a realistic picture of what it is they must defeat. All relevant enemy capabilities must be portrayed and integrated into the scenario in order that the training be truly adequate. Further, the training system must be capable of being updated so that future changes in enemy tactics, weapons, or capabilities can also be represented.

b. Friendly Force/Hardware Capabilities

The training system must be of sufficient detail so that the trainees are acquainted with all of the force capabilities and the hardware capabilities available to them during an armed conflict. Further, the training system must be capable of accurately portraying the effects of both effective and ineffective use of these capabilities, as well as the synergistic effects derived from the use of complementary tactics and complementary hardware systems.

c. The Combat Environment

The training system must be capable of depicting all of the effects that environmental elements have upon the

outcome of battles. For example, it must be capable of accurately portraying the terrain, vegetation, relief, weather, weapons effects, etc., and their impact upon the final outcome. Additionally, the training system must be capable of differentiating between a trainee that makes wise use of these environmental factors (for example, terrain) and that trainee who overlooks their importance.

d. The Mission

For the trainee to truly be prepared for future conflicts, he must be allowed the opportunity to practice dealing with those factors which he is most likely to encounter on the battlefield. Thus, the system must be capable of simulating the various combat mission types that history indicates will most likely confront the trainee battalion commander--such as attack, defend, delay, screen, cover, withdraw, etc.

This is the advantage of a training system such as CATTS; the ability to expose a trainee to the same rigors and situations that he will be exposed to in battle. In order for a training system like this to be effective, it must, as a minimum, consider and satisfactorily deal with the four factors mentioned above, allowing the trainee to cope with the simulated crises and difficult decisions at the same "man-killing" tempo that he will encounter on the battlefield.

3. Training Effectiveness

Training effectiveness has been defined as player acquisition of new skills and knowledge and/or improvement

in performing existing skills and knowledge that result from the interaction with a training system [10]. The training effectiveness of a system must be evaluated in order to insure that the training system is indeed capable of providing the training desired and that the capabilities of the training system are fully implemented to adequately train the students. The goal here is to have the trainee learn as much from the training system as if he had participated in actual combat himself.

Training effectiveness is considered a function of four training effectiveness indicators [10]:

a. Player Exercise Capability

b. Training Process Management

c. Training Vehicle Repertoire

d. System Reliability, Availability, and Maintainability.

a. Player Exercise Capability

Player exercise capability is the extent to which a training system permits players to exercise, practice and apply skills, knowledge, and techniques to be developed through the training. A training system, to achieve any degree of effectiveness, must permit the player personnel an opportunity to practice or apply skills or techniques to be acquired. This facilitates the acquisition process by providing player performance samples for self and instructor critique and the opportunity to take corrective action. Some other considerations are:

(1) Problem Perception

Player problems are generated by training objectives. A player is required by the training exercise to recognize the existence of a problem in his area of responsibility. He must take action on it, to include making decisions, and arrive at a solution following procedures appropriate to his responsibilities, using resources available to him, and taking into account the parameters of the tactical situation. This process is required to teach the player the skills, knowledge, decisions, and actions required of his duty position, and to provide a work sample for evaluation of his level of mastery of required job elements.

To accomplish a training or performance objective and to assess player performance adequacy, players must be confronted with command and control problems to be solved during the course of a scenario. A player will be confronted with stimuli indicating the presence of a problem requiring decision or action. The player must recognize the stimuli, differentiate relevant from non-relevant stimuli, correctly interpret the information, and initiate actions he deems appropriate. The training system must have the capability to present the required stimuli.

A training system should provide the means for a player to take realistic actions on scenario events. Such actions may be correct, incorrect, or irrelevant with respect to events. The response system should permit the player to

take actions peculiar to his duty position to demonstrate that he has detected a problem and he is taking action on it, even though such actions may be incorrect. Feedback or knowledge of the results is necessary to inform players how well they are performing in order to develop the necessary skills. Such feedback should be realistic and in a form of minimum delay; however, in a real time scenario a realistic latency period is desirable.

Acquisition of command and control skills and techniques is also a function, to a certain extent, of the amount of time the players participate in training exercises. The number of players to be trained may restrict the amount of time the players can utilize a training system and associated strategy, thereby reducing the exercise capability and training effectiveness.

(2) Player Preparation Requirement

The player preparation requirement, simply stated, is that the effectiveness of the training system may depend on the professional (military) proficiency, experience, and formal training of the participant.

b. Training Process Management

To insure that intended training objectives and performance standards are attained by the players, the training process must be managed or controlled by the controllers/instructors. Such control entails controller monitoring, evaluation, and critiqueing of player performance and

direction of the training process to insure training objectives are met and performance deficiencies are corrected.

Additionally, the controllers must exert control over the training process to implement a training strategy. The controllers are responsible for establishing conditions that elicit the performance required to insure acquisition and mastery of required skills, techniques, and procedures called out in performance objectives.

Players learn command and control skills and techniques by practice under scenario conditions, reinforced by feedback. In addition to the self-evaluation permitted by the scenario, players can be critiqued by the controllers concerning how well they met performance objectives. In order to critique players, the controllers must have the capability to monitor performance and evaluate it. Some other considerations are:

(1) Problem Control

Problem control is initiated with scenario development. At this stage, events designed to implement training and performance objectives are built into the scenario. A scenario should provide for contingency actions in case the players deviate from the expected courses of action. A set of baseline conditions are required for a point of departure for a training scenario. These are used to read the player into the problem (initial briefing). Subsequent events used to develop teaching points and training objectives build

upon the initial conditions. A minimum level of clarity is required so that the player understands the problem. The ease or complexity of establishing initial conditions will vary with the training system. Further, controllers must monitor the progress of the training scenario to insure that the scenario is operating according to plan and training strategy, and to determine the necessity for implementing contingency plans.

The controllers have the responsibility to insure that training objectives and performance objectives are attained. This requires that they control the direction of the scenario. Further, in order to shorten training time it may be necessary to change the scenario time base during a training session from real time to compressed time and then re-establish real time. Ease of this accomplishment with minimum disruption is a consideration in training system utilization and evaluation.

(2) <u>Player Evaluation</u>

To assure training objectives and performance objectives are met, controllers must monitor and evaluate player actions against performance standards. The ease, timeliness, and completeness of performance evaluation are determined by training system characteristics. Knowledge of performance is utilized to inform players how well they are performing in command and control training scenarios. This information is used to assist players in improving performance in areas of deficiency and to motivate players.

(3) Communications Requirement

A communications system is required to support control of the program of instruction and the scenario and to facilitate player evaluation. The effectiveness of a training vehicle may depend on the type of communications system used.

(4) Controller Requirement

Controllers should meet certain minimum experience and training standards. In order to qualify as controllers of a certain training system, they should be intimately familiar with that training system and its peculiarities.

c. Training Vehicle Repertoire

.Given a set of required training objectives, a training vehicle (i.e., command post exercise, map exercise, etc,) intended to mediate accomplishment of those objectives should have the inherent capability to support the necessary practice exercises and training strategies at some minimum level. The training vehicle should not be too complicated to use and it should be capable of being updated or modified to reflect changes in tactical doctrine, concepts, and organization. Some further considerations are:

(1) Data Base

Utilization of a training system and associated program of instruction requires data and documentation support. Completeness of these factors, ease of their use, and time required to use, can affect training effectiveness

directly or indirectly. It can likewise affect the training costs. The relative ease or difficulty of updating training scenarios should be assessed. This impacts on operational economics and personnel skills required to support a training system.

(2) <u>Problem Configuration Capability</u>

This is the number and type of tactical event elements and combinations of elements available for developing stimulus-response events for a command and control tactical training scenario for use with a training system. This would define the tactical combat model in a computerized system (such as CATTS). Scenario-based instruction requires representation of friendly forces and enemy forces in some degree of detail determined by training requirements. More significantly, this type of scenario-based training requires representation of most types of tactical operations for purposes of command and control practice so that players can learn differences in command problems that are associated with different kinds of operations. Some functions that the system will have to perform using scenario-based instruction are: battle and casualty assessment, mobility assessment, representation of movement rates, terrain, vegetation, visibility, weather, and climate.

(3) <u>Evaluation Feedback Aids</u>

Performance evaluation requires that a training system permit evaluation of player performance by the controllers and the player himself. The effectiveness of a

training system depends in part on how accurately, completely, and timely this evaluation can be made. This in turn is facilitated by the ease of which the controller or player can assess this information. In some cases a training system may preprocess or "highlight" certain performances as an aid to a controller or player. This capability of a system should be assessed. Further points the system should be scrutinized on are:

* The degree of completeness of feedback to players provided by certain systems.
* It is desirable that a training system have a recording and replay capability for purposes of critiqueing players.
* It is desirable that feedback to players be in the form of battle outcomes. This is realistic and provides the players with realistic information concerning the consequences of their command decisions.

(4) <u>Operational and Processing Time</u>

It is desirable that a training system operate in real time or apparent real time for the sake of realism. For training strategy reasons and reasons of economy it may also be desirable that the system operate in compressed time. This capability should be assessed.

d. System Reliability, Availability, and Maintainability

A training system must operate with little or no failure and delay to insure that the training process is not

disturbed, that training is performed as scheduled, and that the program of instruction is successfully completed. Some further considerations are:

(1) Reliability

Lack of training vehicle reliability can lead to failure to accomplish training objectives and performance objectives. Unreliability is also undesirable because training is usually tightly scheduled and may impose an undue maintenance burden on the system support personnel.

(2) Availability

Training system non-availability or delay is undesirable. This factor can result in training objectives and performance objectives not being met, increases in training time and costs, and/or failure to complete training.

(3) Maintainability

A training system should not impose an undue burden on maintenance personnel. A high burden such as this could render the system an uneconomical means of training.

When considering the overall training effectiveness of a training system these four points above must be considered in conjunction with the training strategy employed with the system. A training strategy is a set of procedures employed to guide player learning and to attain the stated training objectives. Several alternative training strategies may be employed with a training system unless the characteristics of the system limit the strategy alternatives to one.

The training system performance can be optimized by a properly designed and implemented strategy or it can be degraded by improperly conceived or implemented training strategies. The current CATTS training strategy calls for utilization of an experiential-type training strategy for players.

To summarize, the evaluation of a training system must first start out with the clear statement of the training system's objectives followed by the statement of the appropriate qualitative effectiveness concepts. An effort must be made to quantify these qualitative measures into measures of effectiveness and if this cannot be accomplished, then surrogate measures must be used. Finally, a training system is further evaluated on its inherent system effectiveness factors in conjunction with the four training effectiveness indicators.

Through the integrated evaluation of the above factors the analyst will be able to reach a satisfactory evaluation of the training system, one that can be used to compare the training system in question with others.

C. THE TEST CONCEPT

The best system found to date by the Army for command and control training at the battalion level is the conventional command and staff training system currently employed at the Command and General Staff College, Fort Leavenworth, Kansas. This type of training uses the classroom techniques of lecture, conference, demonstration, and practical-exercise methods of instruction, e.g., map exercises. The curriculum that is to be tested against the CATTS system can be designed to

accomplish the same training performance objectives as the CATTS training strategy and it can be conducted within the same time constraints. For purposes of test completeness, the performance of CATTS-trained personnel and conventionally trained personnel can be compared with the performance of personnel who have had no other command and control training other than that contained in the appropriate Advanced Course. This group can be used as a control group.

The comparative analysis is designed to answer the following training performance issues:

1. Do CATTS and alternative training systems improve command and control performance?
2. Do CATTS and conventional training approaches differ in training effectiveness?
3. Does prior training and experience of the player affect training performance?
4. Do alternative training systems differ in terms of uniformity of the end-of-training performance produced?
5. Do CATTS training and alternative training approaches benefit on-the-job performance of incumbent staffs? Which training system yields the greatest gains?

This analysis can be easily carried out using the standard statistical techniques only after the appropriate measures of effectiveness have been developed. To date, no such test has been performed. It is the opinion of this author that when

this kind of analysis is finally completed, the CATTS system will be found to enhance the performance and the overall preparedness of future commanders to deal with future battles. More importantly, it is also this author's opinion that the best overall training effectiveness will be attained through a judicious combination of the two training systems: the conventional system to give the trainees a solid background in the fundamentals and the CATTS system to allow the trainee to put his new-found knowledge to use and to sharpen his instincts and reactions in a true-to-life simulation of a battle.

V. SUMMARY AND FINAL COMMENTS ON CATTS

The Combined Arms Tactical Training Simulator indeed promises to bring a new dimension to command and control training for the U. S. Army. Previously, students were constrained to what they could learn from classroom lectures, seminars and the appropriate literature. However, with the appearance of the CATTS system the command and control student can now step into an environment which reproduces the stresses, sights and sounds of combat command as closely and realistically as ever before.

More specifically, some of the other apparent benefits of the CATTS system are:

* Eliminates expensive operation and maintenance of real equipment.
* Saves the time and logistics costs of deploying troops in field exercises.
* Conserves instructor manpower in preparing the conducting command and control training courses.
* Provides more practice under a greater variety of conditions than is feasible in field exercises.
* Furnishes realistic training in geographical areas where live training is not possible.
* Provides training in new tactics and procedures.
* Tests both the planning and the execution of orders in combat.

At the time of this writing, the CATTS system was installed at the Command and General Staff College at Fort Leavenworth, Kansas, where it has been integrated into the curriculum for the purpose of training battalion commanders of the future. Work is also underway to make the CATTS system available to other military bases around the country and around the world so that incumbent staffs could train together with their commanders and develop the required skills and techniques necessary for battlefield success. Studies are also underway to evaluate the possible use of the CATTS trainer as a battalion staff evaluation tool, since there is a fine line between training and evaluation.

CATTS permits future commanders and their staffs to practice commanding and controlling their units--in real time under the most realistic simulated conditions available. The CATTS system is yet to be thoroughly proven, however, the future bodes well for it.

To summarize, this thesis has attempted to acquaint the reader with the Combined Arms Tactical Training Simulator itself, as well as the rationale for its creation. A detailed study of the CATTS system and its major components was presented. Finally, the concepts and methodology appropriate to the evaluation of a system such as CATTS were presented.

BIBLIOGRAPHY

1. Blumenfeld, Warren S. and Holland, Max G., A Model for the Empirical Evaluation of Training Effectiveness, Personnel Journal, Volume 50, Number 8, August 1971.

2. Bode, John R., Indices of Effectiveness in General Purpose Force Analysis, BDM/W - 74 - 070 - TR, Braddock, Dunn, McDonald, Inc., Vienna, Virginia, 1974.

3. Bonder, Seth and Farrell, Robert, Development of Analytical Models of Battalion Task Force Activities, SRL 1957 FR 70-1 System Research Laboratories (SRL), Department of Industrial Engineering, University of Michigan, September 1970.

4. Bonder, Seth, An Overview of Land Battle Modeling in the U. S., published in the Proceedings of the Thirteenth Annual U. S. Army Operations Research Symposium, U. S. Army Concepts Analysis Agency, November 1974.

5. CATTS - Combined Arms Tactical Training Simulator, TRW Systems Group, Redondo Beach, California, 1975.

6. Chesler, D. J., Application and Utilization of Training Aids and Devices: Simulated Exercises and Trainee Performance Evaluation, Research Report SRR 73-7, Naval Personnel and Training Research Laboratory, San Diego, California, September 1972.

7. Department of the Army, Maneuver Control, Field Manual 105-5, December 1973.

8. Haggard, Donald F., Willard, Norman, and Baker, Robert A., An Experimental Program of Instruction on the Management of Training, Technical Report 70-9, Human Resources Research Organization, June 1970.

9. A Hierarchy of Combat Analysis Models, Gaming and Simulations Department, General Research Corporation, McLean, Virginia, January 1973.

10. Ludvigsen, Eric C., CATTS: Simulating a Realistic Enemy, Army, January 1977.

11. Mager, Robert F., Preparing Instructional Objectives, Fearon Publishers, Palo Alto, California, 1962.

12. Marshall, S. L. A., Men Against Fire, William Morrow and Company, New York, 1968.

13. Mathematical Model User's Manual Combined Arms Tactical Training Simulator (CATTS), Device 16A3, Technical Report: NAVTRAEQUIPCEN 73-c-0156-E003, TRW Systems Group, Redondo Beach, California, 1977.

14. The Measurement of Effectiveness, USACDC Pamphlet Number 71-1, U. S. Army Combat Developments Command, Fort Belvoir, Virginia, January 1973.

15. Osborn, William C., Ford, J. Patrick, and Moon, Harold L., Development of New Training Concepts and Procedures for Unit Trainers, Research Report 1189, Human Resources Research Organization, March 1976.

16. Reiman, L. P., If You Want to be Effective, Efficient, and Save Money, Too, Use a Simulator, Marine Corps Gazette, Volume 61, Number 5, May 1977.

17. Stockfish, J. A., Models, Data, and War: A Critique of Conventional Forces, R-1526-PR, The Rand Corporation, Santa Monica, California, March 1975.

18. Taylor, James G., Mathematical Models of Combat, Unpublished Class Handout for OA4654 - Combat Models, U. S. Naval Postgraduate School, Monterey, California, January 1975.

19. Tilley, K. W., Developments in Selection and Training, Ergonomics, Volume 12, Number 4, 1969.

20. Yale, Wesley W., The Acute Need for Simulation Command Training, Military Review, Volume 52, Number 12, December 1972.

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